WHAT IS NEUROSURGERY ?[1]

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I am deeply appreciative of the privilege accorded me, and of the honour done to my specialty, by your invitation to speak to you about neurosurgery. This opportunity is the more pleasing because in no other specialty is there such a vital role for every member of the surgical team as there is in neurosurgery, and the physiotherapist is indeed an important member of this team. The neurosurgical patient — sometimes unconscious for long periods, and commonly suffering disorder of vital brain functions — is more dependent than any other for his very life upon the highest traditions, skills and ethics of our professions.

I do not propose to speak of the anatomy and physiology of motor function, nor of the physiotherapeutic techniques particularly applicable to neurosurgery. Rather would I attempt to give you a broader concept of the problems which you and I face together, and thus my title "What is Neurosurgery?" I shall ask you to consider with me something of its history, methods, problems and results.

THE EVOLUTION OF NEUROSURGERY

Neurosurgery is commonly thought of as one of the more recent and perhaps more exotic branches of surgery. Historically, this is not so, for the operation of skull trephining vies only with circumcision and rhinoplasty for the honour of being the oldest surgical procedure existing virtually unchanged to the present day. Clear evidence is available of its very early practice in ancient Egypt, India, China and Peru. Indeed Thor Heyerdahl, of *Kon-Tiki* fame, has used the practice of skull trephining in certain western Pacific islands as part of his evidence for their colonization from South America.

The reasons for the operation have been lost in the dawn of antiquity. Some allege that early man was prompted by curiosity to open this intriguing box, not then recognized as the seat of the intellect, the emotions, and the will of man. Incidentally, some cynics say that twentieth century man has the same motive — curiosity — for his trephining. Others regard ancient trephining as part of old religious rites, and suggest that some of the mysticism and ritual may be traced in the modern neurosurgical operating theatre. A third view is that ancient man foreshadowed the recent entry of neurosurgery into the psychiatric field by trephining the skull to let out devils.

The first clear evidence of the use of trephining as a therapeutic procedure, in the modern sense, is found in the Hippocratic writings of the sixth and fifth centuries B.C. There, trephining is advised for the removal of bone fragments in the case of depressed fractures, and reference is also made to the relief of hydrocephalus by daily puncture of the lateral ventricles through the anterior fontanelle.

After this, little surgical progress was made until the modern era. The interim was filled by the gradual acquisition of knowledge of the anatomy, and later of the function, of the central nervous system. Of great importance was the discovery of the localization of various functions within the brain, largely by the collection of autopsy material from patients whose symptoms and signs had been studied in life. Special tribute may be paid in this field to the prince of British neurologists, Hughlings Jackson, whose name is remembered in the term "Jacksonian epilepsy", applied to fits localized to one portion of the body, giving evidence of their focal origin on the surface of the brain.

Until the advent of anæsthesia—local and general—in the middle of the last century, operations could not be sufficiently prolonged for the skull to be usefully opened. Until the work of Semmelweiss, Pasteur

[1] Read at the Eighth Biennial Congress of the Australian Physiotherapy Association, May, 1960.

and Lister, fatal infection was the almost constant result of attempts at internal surgery. One final hurdle remained—the control of hæmorrhage from large venous channels in the skull and from delicate cerebral vessels, neither susceptible to simple ligation. The commonest cause of death of neurosurgical patients was then exsanguination upon the operating table. The solution to these problems was found by Sir Victor Horsley, rightly regarded as the founder of modern neurosurgery, at the turn of the nineteenth century. Horsley's bone wax is to be found in every neurosurgical theatre, while his technique of using crushed muscle patches for the control of hæmorrhage persists to this day.

Thus neurosurgery became possible. It remained for Harvey Cushing, brilliant pupil of Osler and of Halsted at Johns Hopkins Hospital, Baltimore, to painstakingly develop all the major operative techniques still in use. His introduction of the diathermy machine for the coagulation of bleeding vessels and for bloodless incision of the brain further advanced the level of hæmostasis, and thus made meticulous surgery possible. Subsequently, his many disciples have extended and modified his work to produce neurosurgery as we know it.

Two other factors have been of great importance. The experience gained by surgeons in two world wars has resulted in greater understanding and more successful treatment of head injuries, whilst blood transfusion and modern anæsthetic techniques have greatly increased the surgical insult that can safely be offered the patient.

Finally, continuing research at hospitals and universities throughout the world leads regularly to further advances, widening the scope of neurosurgery and offering hope to sufferers of a wider range of diseases and disabilities.

NEUROSURGERY TODAY

What is neurosurgery today?

It is the art as much as the science of diagnosis and treatment of surgical diseases of the nervous system. Although it includes the surgery of the spinal cord, the sympathetic nervous system, and the peripheral nerves, its most important part is brain surgery.

Head Injuries

These days of rapid road transport and mechanized industry, which have not been accompanied by any noticeable decrease in the lunatic proportion of *Homo sapiens,* mean that the prime responsibility of the neurosurgeon is the care of patients with head injuries. Road accident is the commonest cause of death among young people, and head injury claims the majority of these. Among the survivors, physical and mental disability as the result of injury constitutes a most serious social and economic loss to the community. And this problem can be expected to increase.

The pattern of injury has changed, for the sudden arrest of a speeding skull when a car crashes results in a brain injury far more widespread and crippling than the simple depressed fracture and concussion likely to be caused by ancient man wooing his fair maiden with a club. This latter injury is likely to be much more innocent than the caveman's intention. Yet behaviour even more primitive than this is often released by a modern head injury, damaging principally the frontal lobes and removing inhibitions, so that one must be constantly on guard against a tendency to resent a patient whose obscenity of speech and behaviour is one of the signs of his injury.

What happens in the common head injury?[2]

The speeding motor cyclist is suddenly arrested when his skull strikes the ground. The skull is stopped suddenly, but the soft brain rushes onward because of its momentum. The effect of this relative movement of brain within skull can be imagined from a consideration of the anatomy of the floor of the skull; the floor of the anterior fossa is rough and the knife-like sphenoidal ridges are prominent. It is over and against these rough surfaces that the brain is thrown. A brain so injured shows bruising and tearing of the frontal lobes and temporal poles, with hæmatomata

[2] Slides were shown to illustrate the following description.

over their surfaces; there is also distortion of the brain and twisting of the vital brainstem. Apart from this surface damage, the whole brain is subjected to stress, and small vessels may be injured deep within it, giving rise to small or large hæmatomata. Such a hæmatoma may rupture through the brain surface.

When one has a clear idea of this type of injury and the widespread damage, it is apparent that one's first duty is to prevent any occurrence that might increase bleeding within bruised and lacerated areas of the brain. Anything that causes venous congestion will increase the likelihood of hæmorrhage, and the most potent and common cause of cerebral congestion is obstruction of the patient's airway by his paralysed palate and tongue falling backward, if he be nursed on his back, or by the inhalation of vomitus or nasal, oral or pharyngeal secretion through the paralysed larynx. "Stertorous respiration" is a fancy way of saying noisy breathing, and noisy breathing is obstructed breathing. Remember, "if the face is blue, the brain is too". Proper care of the patient's respiration is our most important and most rewarding duty.

The part played by the physiotherapist in securing adequate pulmonary ventilation and postural drainage of the lungs will be familiar to you all.

When is operation indicated?

Operation may be necessary because of damage to the coverings of the brain. Lacerated scalps must be sutured, depressed fractures must be elevated, compound fractures must be tidied up, and dural tears that result in leakage of cerebrospinal fluid usually require repair. Finally, operation may be indicated because of compression of the brain by the formation of a hæmatoma on its surface or within its substance.

So rapidly, and yet so insidiously, may intracranial hæmorrhage progress, and so early may its effects become irreversible that the greatest diligence is required for its early detection. Only by intelligent observation of the patient, accurate recording of his state of consciousness and vital functions, and immediate reporting of any sign of deterioration can this lethal condition be diagnosed in time. The prognosis so often depends upon minutes. It matters not whether the hæmorrhage be extradural, subdural or intracerebral, the earliest symptoms and signs are usually increase of headache in the conscious patient and decrease in the level of consciousness. From the onset of the first signs, the situation must be regarded as urgent if good results are to be obtained. If a patient with an extradural hæmatoma is operated upon while still conscious, the mortality rate is less than 5%. But if he be allowed to become comatose, with fixed dilated pupils, the mortality rate is of the order of 75%. It is this urgency that determines the organization of a neurosurgical team, and shortens the temper and regulates the life of the neurosurgeon and his wife.

Cerebral Tumours

The most major and dramatic field in neurosurgery is the treatment of brain tumours, and it is this branch of the specialty that requires the elaborate equipment of the neurosurgical unit. The words "brain tumour" are still regarded by most people and by many doctors as amongst the most despairing in the medical vocabulary. Yet, taking all tumours in the group into account, the prognosis is better as regards length, quality and comfort of survival for brain tumours than for tumours of any other organs excepting the skin, the breast and the large bowel. The surgery of brain tumours presents a formidable challenge, but success is usual unless the nature and site of the tumour weigh the scales too much against us. Of the innocent tumours, meningiomas, which grow from the meninges and compress brain, eighth nerve tumours, which cause deafness and press upon surrounding nerves, cerebellum and brainstem, the tumours of the pituitary gland, which pervert or destroy its function and endanger sight by compressing the optic chiasm, together with tumours of the skull itself, are among the most rewarding of all surgical lesions to treat.

The malignant cerebral tumours (the gliomas, including astrocytomas, glioblastomas (which are the most malignant), ependymomas and medulloblastomas),

which invade and destroy brain, vary enormously in their rate of growth and their susceptibility to treatment. In the most favourable cases, when the tumour is confined to a frontal or temporal pole, or to one hemisphere of the cerebellum, structures which can be removed without too seriously crippling the patient, total excision is possible. This may also be the case when the tumour is but a nodule in the wall of a large cyst which it has produced in the brain. But much more commonly they infiltrate and destroy a large area of the brain. Sometimes their situation is such that any attempt to remove them would result in severe crippling, so that the patient would be too handicapped for survival to be worth while. All that is then done is to take a needle biopsy and depend upon radiotherapy. In other cases—the majority—it is possible to remove most of the tumour, making the removal as complete as is compatible with useful survival. Nice judgement may be needed if one is to fulfil one's obligation to save life, but not to prolong the act of dying.

When removal is incomplete, radiotherapy will often retard the growth of the tumour that remains, and may result in cure. This is particularly the case with gliomas of the optic nerves and brainstem, and with the tumours of childhood. Should radiotherapy fail, further operation or operations may be possible and worth while if recurrence is localized.

In some cases, the most serious immediate effect of the tumour is to obstruct the flow of cerebrospinal fluid within the brain, so that the intracranial pressure becomes extreme. Tumours of the third ventricle may obstruct the flow of cerebrospinal fluid from the lateral ventricles, tumours of the brainstem or cerebellum may block the cerebral aqueduct, whilst tumours of the fourth ventricle will block the whole system. If the tumour cannot be removed, relief of pressure is often obtained by Torkildsen's operation in which rubber catheters are inserted into the lateral ventricles and led beneath the scalp to drain into the cisterna magna beneath the fourth ventricle.

Cerebral Aneurysm

Of all conditions that the neurosurgeon treats, the most challenging and, at the same time, the most perilous is the cerebral aneurysm. It is only in the last decade that this field of surgery has become established, for only in this period have advances in technique of both diagnosis and surgery made procedures of this kind practicable. Even then the subject is contentious, and many physicians are yet to be awoken from their conservatism to a realization that the condition is correctly managed by the surgeon.

Aneurysms tend to develop at weak points on the vessel wall. Some of these weaknesses are congenital, though aneurysms are rarely found before the age of puberty. However, congenital aneurysms are one of the commonest causes of sudden death in young people. The other cause of weakness of a vessel is atherosclerosis, occurring especially in the hypertensive middle-aged patient. Most cerebral aneurysms fall into this group, the maximal age incidence being between 45 and 55 years of age.

Once an aneurysm forms, it tends to enlarge. As this happens the fundus of the sac becomes progressively thinner and weaker. The usual course of events is that a small leak then occurs into the subarachnoid space, causing the extreme headache, neck stiffness, and photophobia which may be diagnostic of subarachnoid hæmorrhage. Following this, some blood clot forms over the aneurysm and hæmorrhage ceases. At the same time adhesions often form, fixing the aneurysm to the brain surface. Over the next few days, the area where the hæmorrhage has occurred undergoes some softening which is maximal between the seventh and tenth days. It is at this stage that complete rupture of the aneurysm often occurs, rupture which may now tear the brain to which the aneurysm is fixed. If, however, the early days are safely passed, the aneurysm wall and its adhesions become gradually stronger, so that at the end of about six weeks most of the danger of a second hæmorrhage has disappeared.

When active bleeding is occurring, nothing can be done for the patient surgically, except, rarely, to evacuate a subdural or intracerebral hæmatoma which is threatening life by compressing brain. Thus urgent surgery is rarely indicated in the treatment of subarachnoid hæmorrhage. Further, immediately after the hæmorrhage the cerebral vessels go into a state of spasm, which increases the danger of surgery. It is partly the release of this protective spasm which is responsible for the common second hæmorrhage in seven to ten days.

What then is the role of surgery?

Few patients die as the result of the first minor leak from an aneurysm. From many patients who are admitted with a disastrous major hæmorrhage, a history can be obtained of symptoms of a minor leak some days earlier. The role of surgery is to prevent the second major hæmorrhage, which will affect at least 50% of patients with a mortality rate of at least 50%.

Thus the surgical approach is as soon as practicable to localize the lesion by angiography and then to operate upon the patient as soon as he is well enough, or before the period of danger, which is seven to ten days.

Two main types of operation are available. For aneurysms which arise directly from the carotid artery, the common carotid artery and sometimes then the internal carotid artery is tied in the neck. The object is to reduce the pressure within the aneurysm to encourage clotting within it. A satisfactory result can be verified by disappearance of the aneurysm in a subsequent angiogram. For aneurysms arising from branches of the internal carotid artery, such as the anterior and middle cerebral and the anterior communicating artery, tying of the carotid in the neck is so seldom effective that it is not practised. The only useful possibility is then to open the head, expose the aneurysm directly, and seal off its neck. This can be done by simple ligation, but more often a small silver clip is compressed across the neck of the aneurysm. Should the neck be of such shape that clipping is impossible, or should it be seen that clipping would endanger vital vessels, all that can be done is to ligate the vessel from which the aneurysm arises if it is dispensable, or to wrap the aneurysm in muscle, or in muslin, in an attempt to strengthen its walls by the formation of a thick scar.

It is this intracranial surgery of aneurysms that creates the greatest tension in the neurosurgical theatre. Most of the aneurysms are relatively inaccessible, so that only a narrow approach is available to them. Should they rupture during retraction of the brain, or dissection of the vessel from which they arise, the situation becomes very serious. Amidst furious bleeding, one must clearly visualize the parent vessel by suction, and then, while holding that vessel to stem the hæmorrhage, complete the dissection of the aneurysm and clip its neck. So free is the anastomosis of the vessels in this area that holding one vessel only may not arrest the hæmorrhage. For this reason, both common carotids are often exposed in the neck before the operation starts, and clamps are applied which can be closed by the anæsthetist should sudden hæmorrhage occur.

Hypotensive anæsthesia has been used to reduce the blood pressure during operations of this sort, and hypothermia is sometimes also employed. The advantage of hypothermia is that it increases the time for which the blood flow can be cut off from any part of the brain without serious damage. At normal body temperature, this is only four minutes, but at 30° C. (86° F.) blood flow can be arrested for ten minutes without damage, giving much more time for the important clipping. However, hypothermia carries its own risks, especially in terms of cardiac irregularity and arrest, and cerebral œdema, so that it cannot be used lightly. What is done is to assess from the radiographs the probable difficulties of the operation. If it is apparent that more than four minutes will probably be needed, then hypothermia may be used.

The surgery of aneurysm is dangerous surgery without doubt. But a successful clipping may restore the patient to normality, and the risks of surgery are considerably less than those of letting the

patient take his chance. As ever, each case must be judged upon its merits, but in all neurosurgery the greater the danger from which the patient is rescued, the greater the reward and satisfaction of helping him.

Other Conditions

Of most other conditions that the neurosurgeon treats I shall say but little. Cerebral arteriovenous malformations may be a cause of subarachnoid and intracerebral hæmorrhage and can often be successfully excised. Cerebral abscess may follow sinus or mastoid infection, or occur as the result of infection elsewhere in the body, and location of the abscess and its treatment by repeated aspiration of pus or by excision, with the use of antibiotics, can be most rewarding. Various other lesions, such as dermoids, hydatids and spontaneous hæmatomas in the brain, are also amenable to treatment.

Hydrocephalus and other developmental abnormalities such as meningomyelocele and encephalocele have a hopeless prognosis if not treated, and sometimes the defect constitutes such a handicap that even the most meticulous treatment available will not materially enhance the child's prognosis. However, some excellent results are obtained and more than compensate for the hearbreak of fruitless endeavour in many cases.

Spinal lesions come within the scope of neurosurgery when the spinal cord or spinal nerve roots are involved. Thus herniated intervertebral discs, especially in the cervical region, and spinal fractures may become our concern. Tumours which compress the cord and produce paralysis also contribute to the variety of our work.

The Relief of Symptoms

Three other situations sometimes requiring surgical intervention merit particular mention. The first is pain.

Pain may be relieved by three means. The first and best is to abolish its cause by curing the lesion that gives rise to it. The second is to administer pain-relieving drugs. But if pain be severe and prolonged, these methods may be unavailing. An example is the intractable pain of inoperable cancer. The neurosurgeon may then be called upon to provide the third means of pain relief, the division of nerves or nerve tracts which convey the painful sensation to the brain. The most common of these operations is spinothalamic tractotomy, or chordotomy, in which the pain pathways in the spinal cord are divided. The severe pain of trigeminal neuralgia is also relieved by the surgical division of the trigeminal nerve.

Another method of relieving pain, particularly pertinent to psyiotherapy, is the recently developed use of percussion or vibration of painful areas. This is appropriate to pain of causalgic type following nerve injury. Examples are amputation stump pain and post-herpetic neuralgia. The rationale is that the pain is of an abnormal type due to perverted stimuli arriving from the injured nerve. These stimuli set up an irritable focus in the spinal cord or brainstem, and this in turn perpetuates a sensation interpreted as pain at the periphery Vibration or percussion of the area of referral bombards the irritable focus with many more stimuli which disturb its pattern and may lead to its dissolution.

Parkinson's disease, characterized by tremor and rigidity of muscles, which may be associated with severe deformities of joints and posture, is a familiar condition for which satisfactory surgical treatment has recently been developed for selected patients whose response to medical therapy is inadequate. The patients who are suitable for operation are those whose life expectancy is reasonably good, whose Parkinsonism is not merely one feature of a general dementia due to arteriosclerosis, and whose degree of incapacity warrants the risks of surgical attack. The technique used varies from clinic to clinic, but the object of treatment is to destrov usually the globus pallidus, but sometimes the ventrolateral nucleus of the thalamus, by mechanical, chemical or electrical means.

The third group of conditions are psychiatric. It has been proven that personality can be altered by division of certain fibres passing to the frontal lobe of the brain. Tension may be reduced,

emotion flattened, and obsessions and fears allayed. In selected psychiatric patients — principally those with severe anxieties and phobias — the operation of prefrontal leucotomy may bring about immeasurable improvement, permitting the rehabilitation of the patient into his family, his employment and the community. At first the operation was too gross, causing far too serious personality change, but the modern conservative procedure has solved this problem. When mental disease has already wrought personality changes that make life scarcely worth while, the surgeon has few qualms about producing a further change which improves the patient's situation.

THE ROLE OF THE PHYSIOTHERAPIST

Now what need has my neurosurgical patient of physiotherapy? He may be unconscious for long periods or short, dependent then upon you for his adequate respiratory function, for the care of skin, for joint and muscle mobility. He may have severe paralysis or sensory loss, or muscular incoordination, and be dependent upon you for re-education. And he may be very dependent upon you for the improvement in morale which so naturally results from contact with the charm for which your profession is noted.

Above all, let us be optimists. Walk around your garden and see that only the weak, the unattractive and the useless—the weeds—grow rapidly. Nature produces good results only slowly. So often we find despair at a patient's slow progress—unconsciousness for even a few days seems grounds for an unreasoning pessimism and pity. Should a man break his femur, no one expects it to mend and function normally immediately, or worries that he is confined to bed away from home and work for weeks. Yet if the brain is damaged we impatiently demand full recovery in a fraction of this time. Patience must be our virtue if we are to do justice to our work.

CONCLUSION

My last remarks are these. Neurosurgery is now no place for the *prima donna* or the single virtuoso. It is the place for the team. The inner medical team consists of neurologist, neurosurgeon, neuroradiologist and neuropathologist, who may consult with ophthalmologist, oto - rhino - laryngologist, psychiatrist, radiotherapist, physician, pædiatrician and so on. And the medical ancillary services, physiotherapy, speech therapy, occupational therapy and almoners' department are all involved, whilst excellent nursing is an essential. It is to this full team that the neurosurgical patient turns in his dire necessity, and into whose hands he commits his life. Upon every member of the team lies the responsibility for his survival and for his rehabilitation to the dignity, the occupation and the pleasure which he should enjoy.